The bugs are too fast

and why we can't catch them.

Kevin Hilman, BayLibre

ATS 2019: Lyon, France

Introductions

BayLibre

- embedded Linux consultancy, engineering services
- based in Nice, France
- ~40 engineers
- open-source focus
  - top 20 Linux kernel contributor
  - top 5 AGL contributor
  - u-boot, Zephyr, ATF, OP-TEE, Yocto

Kevin

- co-founder, Sr. Engineer
- Linux kernel developer and maintainer
- based in Seattle
- co-founder KernelCI project

Agenda

- Kernel testing landscape
- Bugs
- Fragmentation
- KernelCI & Consolidation

Kernel testing landscape

- LTP, kselftest, syzbot, …
- KUnit: unit testing and mocking [1]
  → arch agnostic, can use UML: fast!
  → just merged
- KTF: Kernel Test Framework[2]
  → RFC Aug 12, 2019

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[1] https://google.github.io/kunit-docs/third_party/kernel/docs/
[2] https://lore.kernel.org/linux-kselftest/CAFd5g44-RMaH0kwb+=mW41HO_CgBZ3wK0vnr=Yvb_rE68JazWg@mail.gmail.com/

Kernel testing landscape

- Intel 0-Day and Linux Kernel Performance (LKP)[1]

  → Builds and static analysis for many arches, testing only on x86

- LKFT: Linaro Kernel Functional Tests[2]

  → In-depth testing; Only run tests on Linaro member platforms

- CKI: Continuous Kernel Integration[3]

  → Stable kernel focus: x86_64, arm64, ppc64le

- KernelCI

  → Broad hardware support; very basic test suites

Kernel testing landscape

- Developers, contributors to upstream, maintainers

  → Only run tests on their workstations / dev boards

- Users: distros, OEMs, SoC/CPU vendors

  → Only run tests on their own hardware

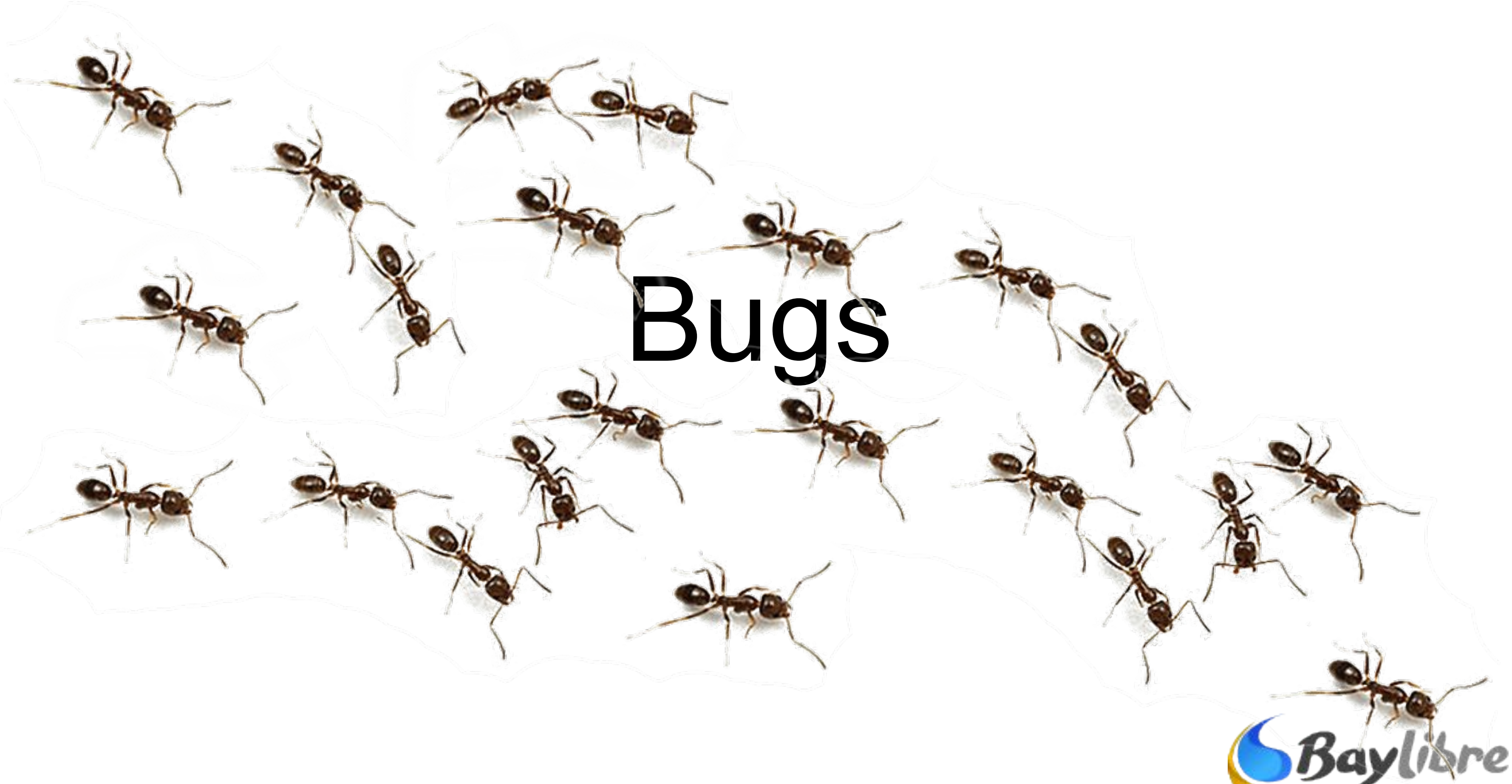
  → Don’t necessarily send fixes upstream

Total test coverage

=

On the beaten tracks

Bugs



`Fixes:` tags

- 2017: **7603**/73873 (**10.3%**)
- 2018: **8947**/75768 (**11.8%**)
- 2019: **8259**/59959 (**13.8%**)
- <½ has `Fixes` tags (40% in linux-4.14.y)

Source: Dmitry Vyukov's LPC2019 talk:
https://linuxplumbersconf.org/event/4/contributions/554/

syzbot bugs

2 years:

- ~2300 bugs upstream (3/day)
- ~2500 bugs in Android/ChromeOS/stable/internal

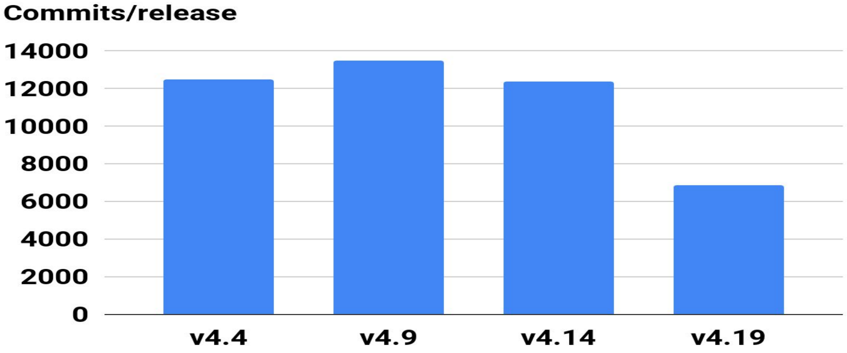
+1000 reported manually before syzbot (~40 bugs/mo for 2 years)

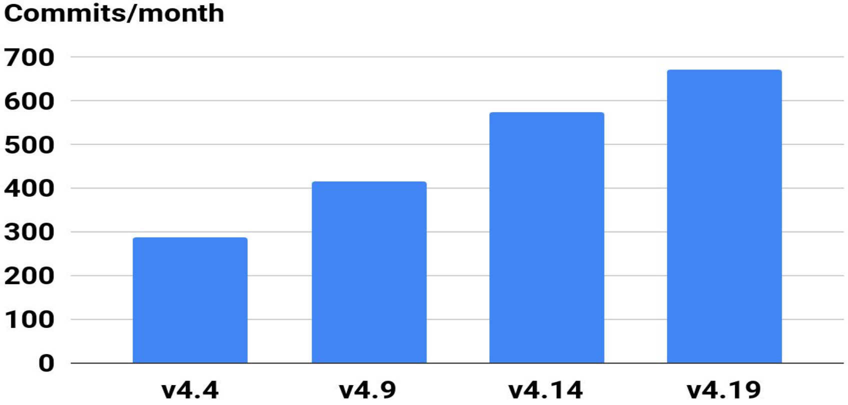
= **5800** bugs

- fuzzing is not supposed to find that many! (simple bugs, broken subsystems)
- only 7% coverage
- only "crashes" (fine with "does wrong thing", bad EINVAL)
- no KTSAN, no KUBSAN

Source: Dmitry Vyukov’s LPC2019 talk

"Stable" releases





+ not backported fixes (700+)
+ not fixed upstream bugs (500+)
+ not found/detectable bugs (???)

>20'000 bugs/release

Source: Dmitry Vyukov’s LPC2019 talk

Buried in bugs. Can we dig out?

Yes, BUT….

Fragmentation

- CI / CD pipelines
- test frameworks
- test suites
- results parsing
- pass / fail criteria
- log collection, aggregation
- results reporting, analysis
- results visualization
- bug tracking
- kernel developer processes for fixes

… and this is is just in the open, community projects.

Conclusion

Fragmentation bad

Collaboration good

Work upstream

No upstream?
create one!

… also for testing & CI

KernelCI status update

KernelCI: off-road testing

Goal: all CPU architectures

Today:
→ x86_64, arm, arm64, mips, arc, riscv

Goal: a wide range of
hardware platforms

Today
→ 35+ SoC vendors
→ 250+ unique boards

KernelCI: multiple build dimensions

Multiple kernel trees

→ mainline, next, stable, stable-rc
→ subsystems: media, sound, clk, soc
→ maintainers, developers
→ android-common, chrome-platform

Multiple compilers

→ gcc, clang
→ multiple versions

Multiple config options

→ all upstream defconfigs (220+)
→ `CONFIG_CPU_BIG_ENDIAN=y`
→ `CONFIG_SMP=n`
→ `CONFIG_RANDOMIZE_BASE=y`
→ and more…

Functional tests

Graphics: IGT (DRM/KMS)
    → Subset run on a handful of devices, gradually expanding

Media: v4l2-compliance
    → Full test suite run on hardware and QEMU (vivid driver)

Power: suspend / resume
    → Run on many boards, finding issues regularly

USB: smoke test
    → Check that the USB subsystem is initialised

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Consolidation, Collaboration, Community

- Membership based, Sustainable funding
- Open testing philosophy
- KernelCI as open-source software
- KernelCI as a service: kernelci.org
- Founding members:
    - Collabora, BayLibre, Google, Microsoft, RedHat, CIP, Foundries.io

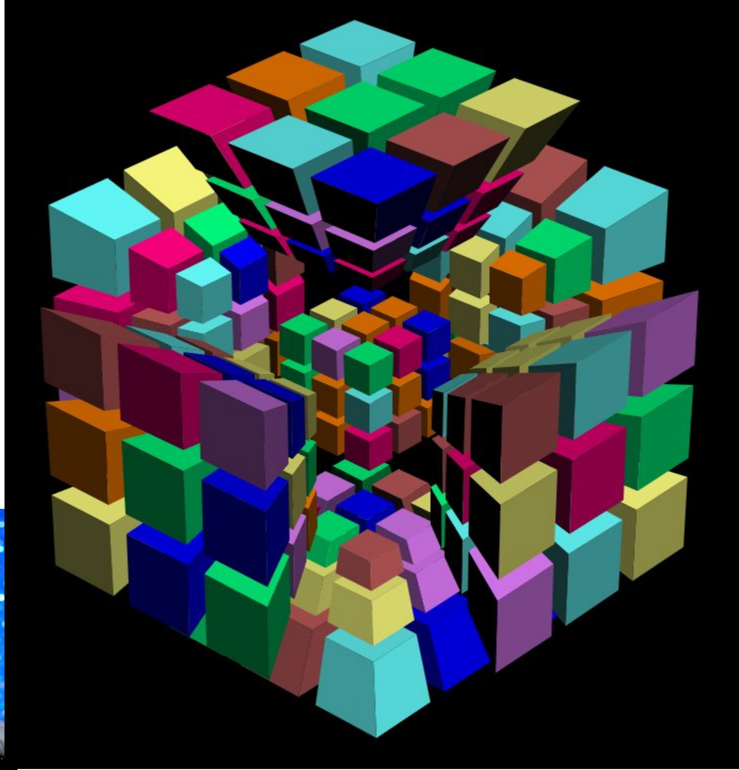
Challenge: data is growing

Matrix is expanding

Collecting lots of data, results, logs, artifacts

Storage, Analytics, Visualization, Reporting

Big Data?



What’s next?

Collaboration: LKFT, CKI, Fuego...

Improve reporting, analytics, visualization, reporting, etc.

More hardware, more compute

Other CI pipelines (gitlab CI,...)

More tests: fuzzing, KUnit?

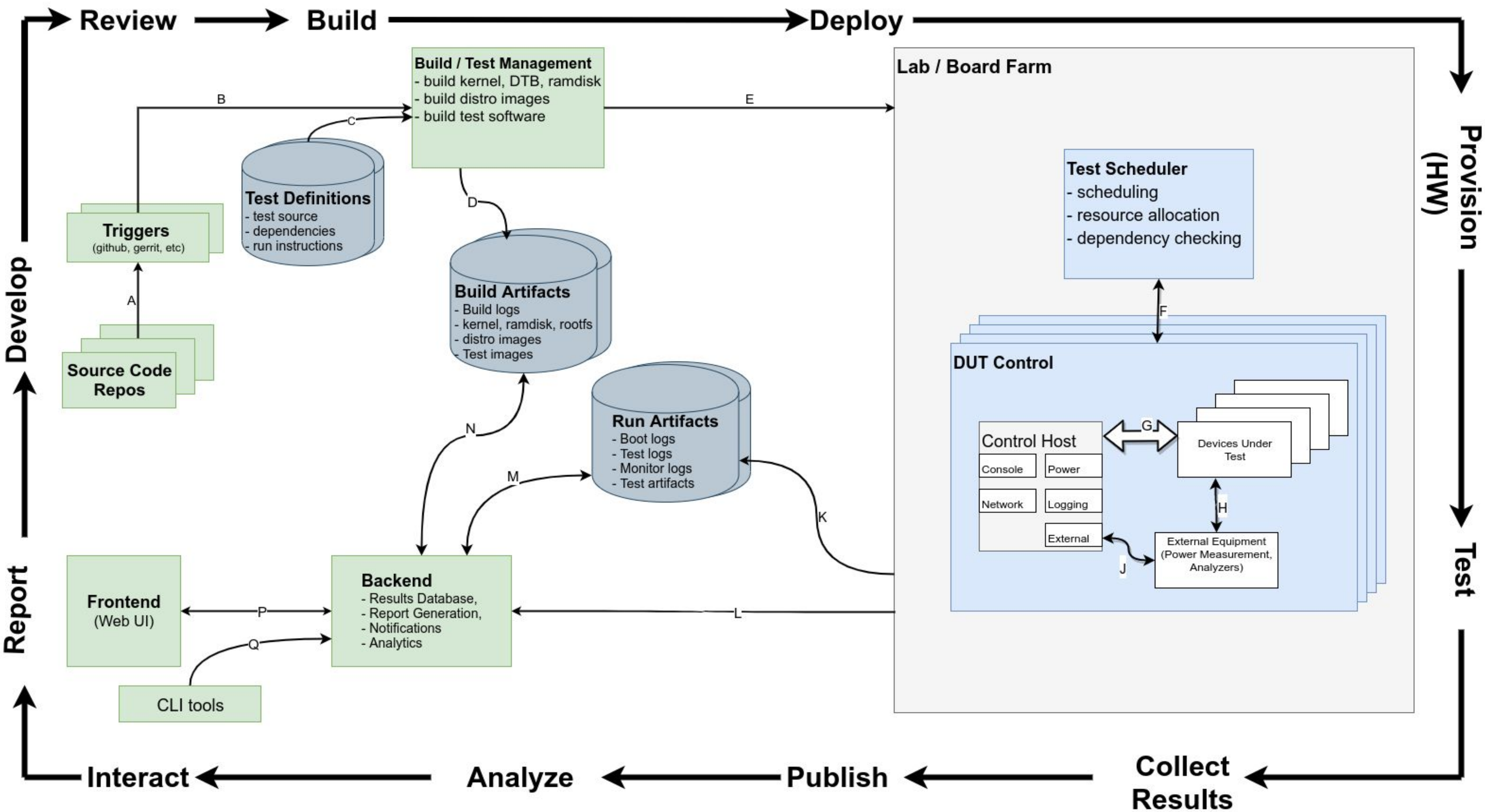
Distro kernels, Yocto?

Join the project and help decide!

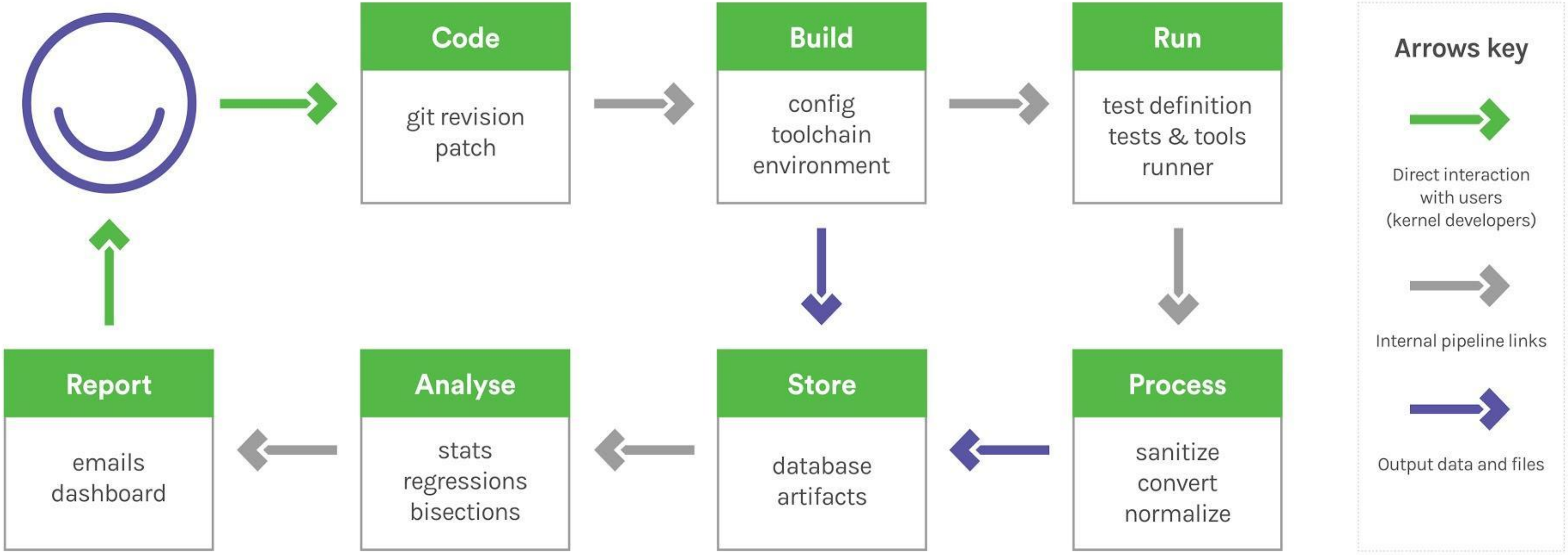
Open testing philosophy

We like open-source software

What about open-source testing?


Review
Build
Deploy
Provision (HW)
Test
Collect Results
Publish
Analyze
Interact
Report
Develop
Build / Test Management
- build kernel, DTB, ramdisk
- build distro images
- build test software
Triggers
(github, gerrit, etc)
Source Code Repos
Test Definitions
- test source
- dependencies
- run instructions
Build Artifacts
- Build logs
- kernel, ramdisk, rootfs
- distro images
- Test images
Run Artifacts
- Boot logs
- Test logs
- Monitor logs
- Test artifacts
Lab / Board Farm
Test Scheduler
- scheduling
- resource allocation
- dependency checking
DUT Control
Control Host
Console
Power
Network
Logging
External
Devices Under Test
External Equipment (Power Measurement, Analyzers)
Frontend
(Web UI)
Backend
- Results Database,
- Report Generation,
- Notifications
- Analytics
CLI tools
A
B
C
D
E
F
G
H
J
K
L
M
N
P
Q

KernelCI Modular Pipeline



Code
git revision
patch

Build
config
toolchain
environment

Run
test definition
tests & tools
runner

Process
sanitize
convert
normalize

Store
database
artifacts

Analyse
stats
regressions
bisections

Report
emails
dashboard

Arrows key

→ Direct interaction with users (kernel developers)

→ Internal pipeline links

→ Output data and files

github.com/kernelci/kcidb

THANK
YOU

Photo credits

agenda: https://pixabay.com/photos/agenda-appointment-calendar-coffee-2296195/

landscape: https://www.flickr.com/photos/hemlit/8212362709/

sand: https://www.flickr.com/photos/156754622@N02/23962149187/

thank you: https://flic.kr/p/bGhz

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obvious: https://www.flickr.com/photos/emmajane/2580835224

ants: http://pngimg.com/download/19357

snow: https://www.flickr.com/photos/waynethume/4335043665

big data: https://flic.kr/p/deKzer

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